

Chapter 22

Low-Temperature/High-Temperature Thermal Desorption

22-1. General.

The processes, applications, and limitations of low-/high-temperature thermal desorption are described in the chapter's first section. The second portion of the chapter is a hazard analysis with controls and control points listed.

22-2. Technology Description.

a. Process.

Low-temperature and high-temperature thermal desorption treat wastes by distilling (evaporating) water and organic compounds from the feed solids such as soils (see Figure 22-1). These processes are physical separation methods and are not designed to directly destroy organic compounds. Consequently, these processes can operate at lower temperatures than incineration. In practice, the off gas laden with the evaporated contaminants is often incinerated in higher temperature, smaller, and more economical secondary burner/incinerators. However, the off-gas contaminants can also be condensed for disposal or reuse. The terms low- and high-temperature thermal desorption are somewhat arbitrary classifications, since most units can operate across a range of temperatures, and the high- and low-range systems overlap considerably in capability. Oxidation is controlled by adjusting the bed temperatures and residence times in the system.

Excavated soil or solids are homogenized and oversized rejects are removed prior to feeding the soil into the desorption system. Two common thermal desorption systems are the rotary dryer and thermal screw. Rotary dryers are horizontal cylinders that are inclined and rotated during firing. Thermal screw units utilize screw conveyors or hollow augers to transport the medium through an enclosed trough. Hot oil or steam circulates through the auger to indirectly heat the medium. Particulates generated during desorption are removed by wet scrubbers or baghouse (fabric) filters. Volatile contaminants are purged with a carrier gas or vacuum system and are removed through condensation followed by carbon adsorption, or they are destroyed in a secondary combustion chamber or catalytic oxidizer. The treated medium is returned to the excavation after testing.

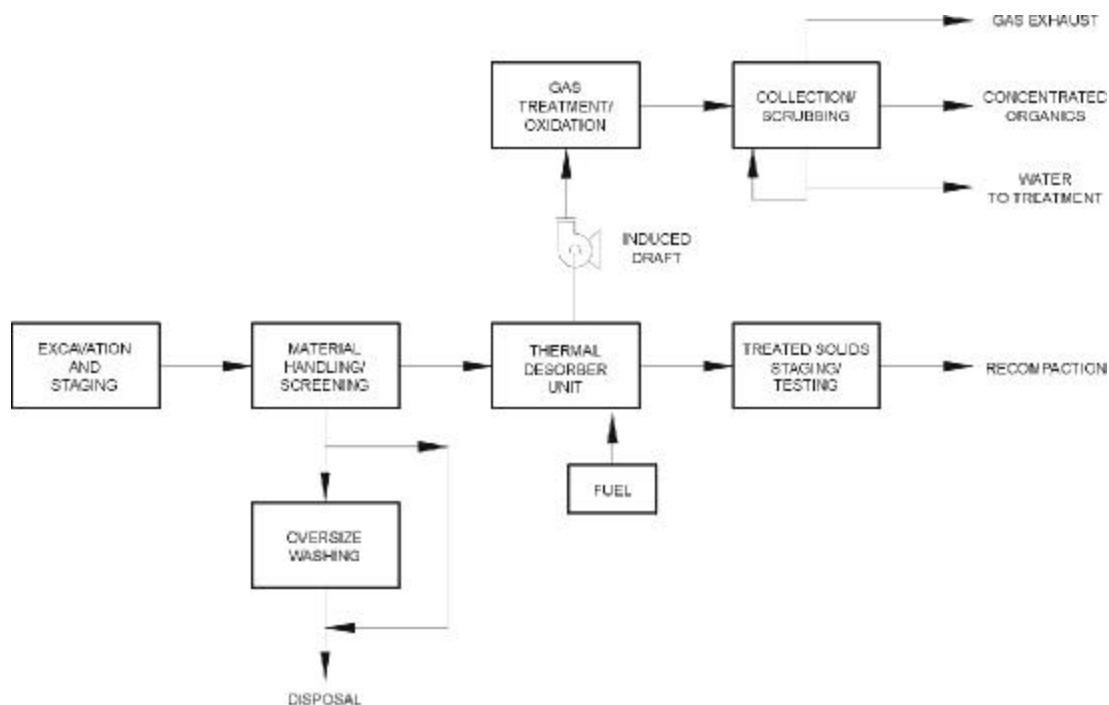


FIGURE 22-1. TYPICAL PROCESS FLOW FOR LOW-TEMPERATURE/ HIGH-TEMPERATURE THERMAL DESORPTION

b. Applications.

Low-temperature thermal desorption systems are effective for the removal of nonhalogenated and halogenated volatile organic compounds (VOCs) and petroleum hydrocarbons. Semi-volatile organic compounds (SVOCs) can be treated with reduced effectiveness. Soil decontaminated with a low-temperature thermal desorption system retains its physical properties.

High-temperature thermal desorption systems are effective for the removal of VOCs, SVOCs, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, coal tar wastes, creosote-contaminated soils, paint wastes, and mixed (radioactive and hazardous) wastes. Volatile metals may be removed by high-temperature thermal desorption systems. Soils treated with high-temperature thermal desorption may lose many of their soil properties and may need to be amended if expected to provide structure. Systems for both technologies are available as transportable units that can be mobilized to sites.

c. Limitations.

Limitations are similar in both systems. Dewatering of the feed soils may be required to reduce the amount of energy required to heat the soil in both the low- and high-temperature thermal desorption systems. Clay and silt-based soils or high humic content soils may increase the required residence times due to binding of organic constituents. Heavy metals in the soil may produce a residue that requires stabilization prior to returning it to the excavation. Feed particle size limitations can impact applicability and cost for specific soil types, and abrasive feed streams may damage the processor unit.

22-3. Hazard Analysis.

Principal unique hazards associated with low-temperature/high-temperature thermal desorption, methods for control, and control points are described below

a. Physical Hazards.

(1) Noise Hazards.

Description: Desorption treatment units may expose workers to elevated noise levels in the work area due to the operation of air blowers, pumps, and the ignition of fuels within the combustion chamber. The noise level may interfere with safe and effective communications.

Control: Controls for noise hazards include

- Follow the regulatory requirements of CEGS 02289 (Remediation of Contaminated Soils by Thermal Desorption).
- Use hearing protection and establish a hearing protection program (see 29 CFR 1910.95).
- Use personal electronic communications devices, such as a dual ear headset with speaker microphone, to overcome ambient noise. The device reduces ambient noise levels while enhancing communication.
- Establish noise-free areas during operations to provide breaks from the noise, which can cause fatigue and inattention.

CONTROL POINT: Design, Operations

(2) Fire or Explosion (High Operating Temperatures).

Description: Thermal desorption units that are not operated below the ASTM E953-determined ash fusion temperature may cause the solid waste material to vitrify into a large, hot mass within the unit. The resulting heat and pressure buildup may exceed the equipment pressure rating of the unit, possibly causing a fire or explosion or release of the vitrified waste materials during operation or maintenance.

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Control: Controls for fire and explosion include

- Operate the unit following the instructions in CEGS 02289, Remediation of Contaminated Soils by Thermal Desorption. This standard, in part, requires:
 - A Startup Plan.
 - A Proof of Performance Plan listing the proposed operating conditions for process parameters to be continuously monitored and recorded.
 - An Operating Plan specifying detailed procedures for continued operation of the system, based on the proof of performance results.
 - A Demobilization Plan.

CONTROL POINT: Design, Operations, Maintenance

(3) Flammable/Combustible Fuels.

Description: Thermal desorption usually requires storage of flammable or combustible fuels (e.g., kerosene, waste fuels). Hazards associated with flammable/combustible fuels include the potential for on-site spills or release of material. The release may cause worker exposure to the vapors generated, or a fire hazard may exist if the material is ignited.

Control: Controls for flammable/combustible fuels include

- Use appropriate tanks, equipped with pressure-relief devices and bermed to help prevent release of material.
- Use electrical equipment and fixtures that comply with NFPA 70.
- Follow CEGS 02289 (Remediation of Contaminated Soils by Thermal Desorption). It requires that fuel system installation/storage/testing comply with: NFPA 30 (Flammable and Combustible Liquids Code); NFPA 31 (Installation of Oil Burning Equipment); NFPA 54 (National Fuel Gas Code); or NFPA 58 (Standard for the Storage and Handling of Liquefied Petroleum Gases).
- Ventilate the area adequately to help prevent the accumulation of flammable vapors.
- Permit only trained and experienced workers to work on the system.
- Use lock-out and tag-out procedures on all electrical systems during repair or maintenance.

CONTROL POINT: Design, Construction, Operations, Maintenance

(4) Ignition of Saturated Soils.

Description: During excavation of waste materials with low flash points, saturated soils may be ignited by sparks generated when the blade of the dozer or crawler contacts rocks or other objects under unusual or extraordinary conditions. If the soil will be crushed prior to feeding into the desorption unit, waste materials with higher than expected BTU values may ignite during the crushing/sorting process.

Control: Controls for ignition of saturated soils include

- Apply water periodically to the soils (before and during crushing).
- Equip soil-handling equipment with non-sparking buckets or blades.

CONTROL POINT: Operations

(5) Fire or Explosion (High-BTU Feed).

Description: If the BTU value of the waste feed is not controlled and high-BTU feed enters the desorption unit, the temperature of the unit may exceed design specifications, possibly resulting in fire or explosion.

Control: Controls for fire include

- Use experienced operators and supervisors.
- Audit and apply proper QA/QC to assure that the unit is operating according to design and that the waste feed has a consistent BTU value based on design parameters.

CONTROL POINT: Design, Operations

(6) Electrocution.

Description: Since desorption treatment units operate electrical systems outdoors, workers may be exposed to electrocution hazards if the electrical equipment comes in contact with water.

Control: Controls for electrocution include

- Verify that drawings indicate the hazardous area classifications as defined in NFPA 70-500-1 through 500-10.
- Use controls, wiring, and equipment with adequate ground-fault protection that meet the requirements of EM 385-1-1, Section 11.G; and NFPA 70.
- Use adequate ground-fault protection.

CONTROL POINT: Design, Construction, Operations, Maintenance

(7) Transfer Equipment Design.

Description: All transfer equipment (conveyors, piping, process units, and instruments) in contact with contaminated materials should be fabricated from materials that are chemically resistant to the given contaminant chemical. Improperly designed systems can corrode or dissolve, causing damage to the facilities or exposing workers to collapse hazards from falling equipment.

Control: Controls for transfer equipment include

- Use equipment fabricated from materials that are chemically resistant to contaminants in the system.
- Chemical resistance charts are available through the National Association of Corrosion Engineers (NACE).
- Install spill and/or leak detection instruments if necessary.

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- Include containment drip pans or receivers where liquids may separate from solid materials.
- CONTROL POINT: Design, Construction, Maintenance

(8) Burn Hazards.

Description: The thermal desorption process may use high temperatures to heat materials. The materials that are processed will exit the system hot, exposing workers to possible thermal burn hazards.

Control: Controls for burns include

- Use temperature safety control systems to protect people and equipment.
- Post signs warning of high temperatures.
- Use safety barriers to isolate critical sections of the equipment.
- Design systems to handle the materials exiting the system. Follow NFPA 30, 31, and 54 and CEGS 02289 (Remediation of Contaminated Soils by Thermal Desorption) criteria.
- Use heat resistant gloves to help prevent thermal burns.

CONTROL POINT: Design, Operations, Maintenance

(9) Transfer Systems.

Description: Transfer systems such as screw conveyors or augers expose workers to injury if limbs or clothing are caught in the system.

Control: Controls for transfer systems include

- Enclose transfer systems to the maximum extent possible.
- Install emergency shutoff controls in multiple locations.
- Enforce lock-out/tag-out procedures rigorously.
- Train workers in identification of pinch points in the system.

CONTROL POINT: Design, Operations, Maintenance

(10) Respirable Quartz.

Description: Depending on soil types, exposure to respirable quartz may be a hazard. Consult geology staff to confirm the presence of a respirable quartz hazard (e.g., to determine if soil types are likely to be rich in respirable quartz). As an aid in determining respirable quartz exposure potential, sample and analyze site soils for fines content by ASTM D422, followed by analysis of the fines by X-ray diffraction to determine fine material quartz content.

Control: Controls for respirable quartz include

- Wet the soil periodically with water or amended water to minimize worker exposure.
- Use respiratory protection, such as an air-purifying respirator equipped with a HEPA (N100, R100, P100) filter.

CONTROL POINT: Construction, Operations**(11) UV Radiation.**

Description: During site activities, workers may be exposed to direct and indirect sunlight and the corresponding UV radiation. Even short-term exposure to sunlight can cause burns and dermal damage. Hot and humid conditions may also result in heat stress, which can manifest itself as heat exhaustion and heat stroke.

Control: Controls for UV radiation include

- Minimize direct sun exposure by wearing sun hats, long-sleeved shirts, full-length pants, and by applying UV barrier sunscreen.
- Shade work and break areas, if possible.
- Minimize exposure to heat stress conditions by taking frequent breaks, drinking adequate fluids, and performing work during the early morning and late afternoon hours.

CONTROL POINT: Construction, Operations**(12) Electrocuting Hazards.**

Description: Workers may be exposed to electrocution hazards when working around electrical utilities such as overhead power lines.

Control: Controls for electrocution include

- Verify the location of overhead power lines, either existing or proposed in the pre-design phase through contacting local utilities.
- Keep all lifting equipment at least 10 feet from the power line according to Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1926.550 and EM 385-1-1, Section 11.E.

CONTROL POINT: Design, Construction, Operations**(13) Traffic Hazards.**

Description: During the implementation of field activities, equipment and workers may come in close proximity to traffic. Also, equipment may need to travel or cross public roads. The general public may be exposed to traffic hazards and the potential for accidents.

Control: Controls for traffic hazards include

- Post warning signs according to the criteria of the Department of Transportation Manual on Uniform Traffic Devices for Streets and Highways.
- Develop a traffic management plan before remediation activities begin to help prevent accidents involving site equipment. EM 385-1-1, Section 21.110 provides plan details.

CONTROL POINT: Design, Construction, Operations

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(14) Heated Surfaces.

Description: Workers may be exposed to infrared radiation hazards associated with working in the vicinity of thermal desorbing treatment units. The exposure, depending on the temperature of the equipment, length of exposure, and other variables may increase the risk of cataracts.

Control: Controls for heated surfaces include

- Minimize worker exposure to heated equipment surfaces.
- Use eye protection with the appropriate shade safety glass if prolonged work is required.

CONTROL POINT: Operations, Maintenance

(15) Confined Spaces.

Description: Workers may be exposed to confined-space hazards during entry into the process equipment for repair, inspection, or maintenance activities. Confined-space hazards may include injury by release of hot, vitrified waste material; exposure via the inhalation route to toxic materials (e.g., vinyl chloride); and/or exposure to an oxygen-deficient atmosphere or entanglement.

Control: Controls for confined spaces include

- Test the atmosphere within the confined space prior to entry (see 29 CFR 1910.146).
- Design air-handling systems to minimize or eliminate oxygen-deficient locations.
- Use air-supplied respirators to help control inhalation exposures to toxic chemicals (e.g., vinyl chloride) or to help prevent asphyxiation.
- Allow process equipment to cool completely and thoroughly inspect to identify build-up of vitrified waste material within equipment prior to entry.

CONTROL POINT: Operations, Maintenance

(16) Predesign Field Activities.

Description: Predesign field activities associated with subsequent construction may include surveying, biological surveys, soil gas surveys, geophysical surveys, trenching, drilling, stockpiling, contaminant groundwater sampling, and other activities. Each of these field activities may expose the survey personnel to physical, chemical, radiological, and biological hazards.

Control: Controls for hazards resulting from predesign field activities include

- Prepare an activity hazard analysis for predesign field survey activities. EM 385-1-1, Section 1.A provides guidance on developing an activity hazard analysis.
- Train workers in hazards identified.

CONTROL POINT: Design**b. Chemical Hazards.****(1) Waste Material Exposure (Excavation and Transport).**

Description: Worker exposure to waste materials may occur during excavation and transport of waste materials. Dry soils may generate airborne dusts contaminated with toxic materials (e.g., respirable silica, metals, semi-volatile organics, pesticides, etc.).

Control: Controls for waste material exposure include

- Wet dust periodically to prevent airborne dust generation.
- Use respiratory protective equipment such as an air-purifying respirator with approved filter/cartridges like HEPA (N100, R100, P100) for particulates; OV cartridges for vapors; or combination filter/cartridges for dual protection.

CONTROL POINT: Operations**(2) Waste Byproducts.**

Description: During operation of the desorption unit, workers may be exposed to byproducts of incomplete combustion such as carbon monoxide or to airborne toxic materials, including metal acetates, mercury, and chlorine.

Control: Controls for waste byproducts include

- Classify wastes prior to desorption. Feed only those waste materials compatible with the process into the unit.
- Design the process and off-gas treatment to control generation and release of toxic materials.
- Use necessary PPE such as an air-purifying respirator equipped with HEPA (N100, R100, P100) filters appropriate for the contaminants of concern and air emissions controls if necessary.

CONTROL POINT: Design, Operations**(3) Waste Material Exposure (Desorption Unit).**

Description: During maintenance of the desorption unit, workers entering the unit for cleaning, inspection, or repair of equipment may be exposed to waste materials or incomplete combustion byproducts (e.g., metal acetates, mercury, chlorine, etc.). In addition, workers may be exposed to toxic vapors or an oxygen-deficient atmosphere by entering into confined space.

Control: Controls for waste material exposure include

- Use confined-space entry procedures if appropriate (see 29 CFR 1910.146).
- Assess the hazard exposure at the time of entry.
- Wear appropriate PPE.

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- Design the facility and unit for ease of cleaning and maintenance to minimize the frequency, duration, and extent of exposure.

CONTROL POINT: Design, Maintenance

(4) Exhaust Vapors.

Description: Workers may be exposed via the inhalation exposure route during the thermal desorption process. Since some chemical contaminants, such as fuel oils, are not completely destroyed in the process, they may be discharged via the exhaust stack into the work area.

Control: Controls for exhaust vapors include

- Gather exhaust vapors for further processing in an off-gas treatment unit (e.g., vapor carbon beds, incinerators, thermal oxidizers, or gas scrubbing towers). Fugitive emissions are possible if systems are not designed to address these issues.
- Do not operate systems at less than atmospheric pressures to eliminate fugitive emissions problems.

CONTROL POINT: Design, Operations

(5) Toxic Dust.

Description: If the soil or materials being treated are rich in silica-based materials such as quartz, worker exposure to crystalline silica dust may occur. Soils composed of silt and clays are likely to create atmospheres with high respirable dust concentrations.

Control: Controls for toxic dust include

- Keep feed material and ash slightly moist to suppress dust.
- Perform adequate maintenance and seal all leaks in the thermal treatment system to reduce the generation of emitted silica or other dust.
- Consult geotechnical staff to determine if site-specific soils are rich in quartz particles.
- Provide air-purifying respirators with HEPA (N100, R100, P100) filters at a minimum.

CONTROL POINT: Operations, Maintenance

c. Radiological Hazards

Unique radiological hazards are typically not associated with this technology. Consult with a certified health physicist if mixed or radioactive waste is being treated to identify potential radiological hazards during design.

d. Biological Hazards.

No unique hazards are identified.